6.1 COOPERATIVE LANDER-ROVER –BIOMORPHIC EXPLORERS MISSION

When exploring a new terrestrial/planetary surface *in situ*, the challenge is to be able to quickly survey and select the sites of interest. Imaging done from orbiters currently allows broad coverage but at limited spatial resolution; ~ 60 cm to 1m/pixel. Descent imaging may provide a context for landed vehicles; however, it is not broad enough to plan exploration paths/areas for a rover or to characterize potential sample return sites. Images taken from surface-sited landers/rovers with masts ~1- 2 m high do not cover the surroundings adequately far from their location. Coverage of a large area is warranted, and close up imaging (~5 – 10 cm resolution) and in-situ imaging at even greater resolutions is desired. The essential mid-range, 50 – 1000-m altitude perspective is as yet uncovered and is an essential science need. Imaging from this mid-range is required to obtain details of surface features/topography, particularly to identify hazards and slopes for a successful rover mission. For a planet with an atmosphere, such as Mars, flyers carrying cameras can provide the larger-scale visibility at the required spatial resolution within the context of orbiter and/or descent imaging. A cooperative lander-rover-biomorphic explorers mission is therefore suggested and illustrated in figure 8.

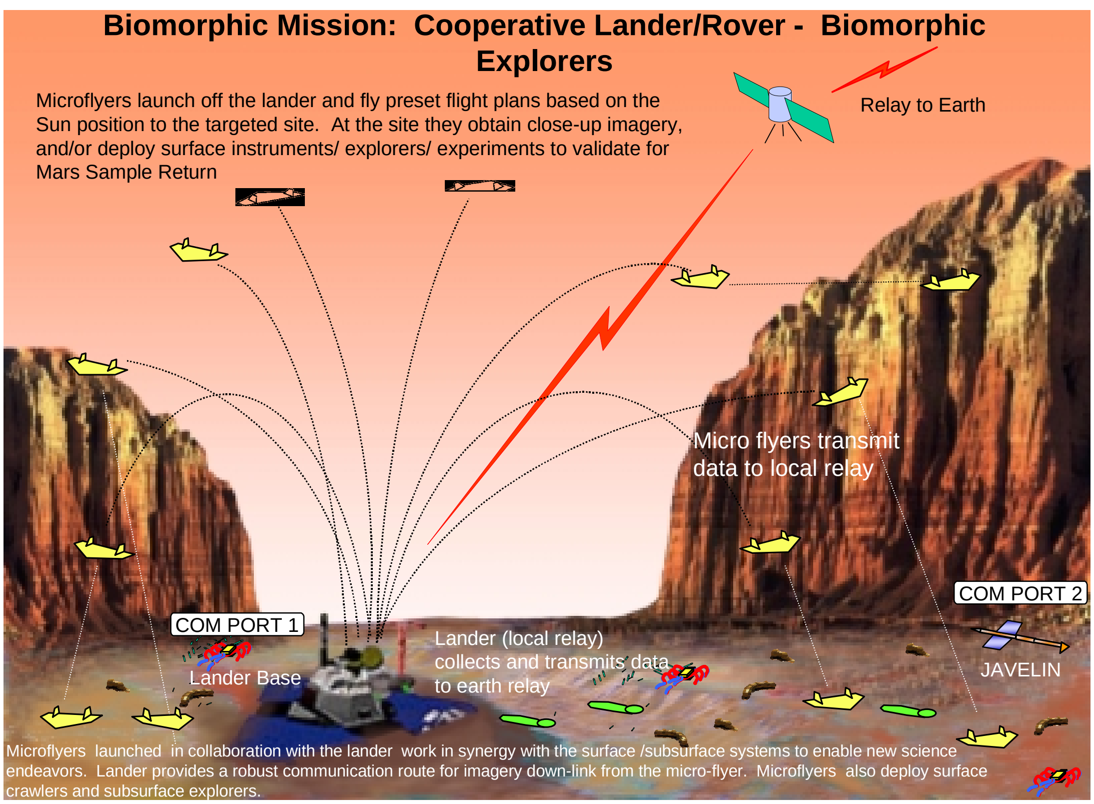

Figure 8: Biomorphic Mission: Cooperative Lander/Rover - Biomorphic Explorers

The mission[50] objective is to perform close up imaging of 'over the horizon' terrain and perform in-situ surface measurements for site selection and sample return reconnaissance. A specific objective is to obtain samples from potential exobiology sites and areas of geological interest on Mars. Valles Marineris on Mars is a potentially favored landing site because, by comparison with our Grand Canyon here on Earth, it is expected to be potentially rich in geological data in one single site. Additionally, if accessible, it will be possible to sample the whole section from top to bottom from one single landing site. Bridger[51] has proposed a study of the entire stratigraphic column exposed along the canyon wall. Lucchita[52] has described Valles Marineris as an optimum science sample site. A lander equipped with a large rover (and ascent vehicle) or a large rover-lander lands in the Valles Marineris roughly 10-100 km from an area of potential exobiological significance including fault zones with exposed geological features, and eroded canyon walls with exposed sedimentary layers. The lander or rover-lander is targeted in a relatively flat area (possibly devoid of interesting samples) to minimize risk in landing. The rover is designed for traversing rugged terrain and is equipped with an arsenal of scientific experiments including the ability to obtain and store samples. The rover is heavily instrumented and therefore quite expensive and by no-means expendible. However, there is always a risk of damage or loss in negotiating the rugged terrain. Therefore, some knowledge of the terrain and locations of scientific targets can significantly reduce mission risk and improve sample collection efficiency. After shedding the protective gear and making necessary deployments, a javelin is launched from the lander, and lands ~ 500m –1Km away. The javelin and lander begin emitting low-power RF signals, which will be used for radio navigation by the microflyers and other explorers. The canyons in the foothills of the Valles Marineris are varied, some with steep walls and rubble at the base; others are filled with wind-blown sands. Many canyons end abruptly after a short distance or become impassable due to rockslides. From its vantage point in the valley, the lander cannot determine the location of ideal science targets or the best paths to reach them. The rover could waste a tremendous amount of time searching for a suitable path and going down dead ends.

The lander or rover-lander is equipped with several microflyers. A launching mechanism is used to launch the microflyer towards the target site specifying a flight heading. Launch energy could be provided by a small solid rocket, pneumatic thrust, compressed *in-situ* resource gas launch, a spring, electrically powered launch or a mechanism combining two or more of the stated techniques. The communication range is kept small (<10 km), and the lander local relay base is always available. Different flight paths over different terrains of interest are followed by the different flyers. Surface imagery is obtained using miniature camera systems on the flyers. The microflyer relays imagery/meteorological data to the lander and after landing conducts/deploys a surface experiment and acts as a radio beacon to indicate the selected site.

This particular flyer also can be equipped with the logic to identify specific features that may signify an area of scientific interest. The flyer then makes a decision to terminate the flight when its sensor identifies a potential exobiological site. Its small size, low mass and rugged design enable it to survive the impact with the ground. It then deploys a small science experiment with a chemical or pyrotechnic device and a "sniffer" to determine the presence of some trace element. Perhaps this experiment might even burrow several centimeters below the surface. The flyer then uses its remaining power and the power from a small photovoltaic cell to periodically transmit the results of its tests. This transmission also acts as a beacon.

The lander receives the images and beacon signals transmitted by the flyers and relays them to the science team and mission planners on Earth. Several other flyers are launched in succession, each on its own radial, and the images and data are collected and sent to the project team. Based on this data, the project team identifies target sites with the greatest science potential, and suitable pathways are mapped.

The rover then begins its mission with numerous radio beacons aiding in its navigation. Along the way, the rover finds itself unable to negotiate a way around some fallen rock and debris. The rover itself carries several flyers, designed for slow flight, and deploys one to survey the area. Also, the rover could carry several microflyers to allow functional subdivision. Using the rover as a beacon, the flyer takes images of the rover and surrounding area while sending the images back to the lander. Mission planners are able to use the information to plan an effective route not to mention getting an image of the rover in a rugged remote location for the media. Little time is wasted and the risk is minimized. The rover executes its mission plan and obtains samples from several sites before returning to the lander and depositing the samples into the ascent vehicle. Microflyers launched from the lander or rover-lander could also disperse other biomorphic multiterrain surface or subsurface explorers. These tiny multiterrain explorers could be the climbing type or rapelling type, scaling the columns of Valles Marineris obtaining close-up stratigraphic data. Microflyers could also be used to send the samples back to the lander for collection. In this reconnaissance role the microflyers maximize the effectiveness of the larger rover-lander.

If the feasibility of this approach can be verified, use of surface-launched imaging microflyers would be a powerful option for enhancing the public interest and science return from a Mars '05 and/or '07 rover or sample return mission. Use of flyers at Mars would have great public appeal. The unique perspective of the images acquired from such flyers will excite the public as well as provide valuable mission support. The chances of selecting the most interesting sites for visitation by a rover within the limited time and resources of the mission could be increased dramatically. Identification of the most interesting specimens to be collected as returned samples could be enabled over a much wider area than could be done from the rover directly. In these ways, the scientific return from a rover mission would be increased. Further development of a planetary flyer capability will also have potential application to future missions to other planets and satellites with atmospheres such as Venus, Jupiter, Saturn, and Titan.